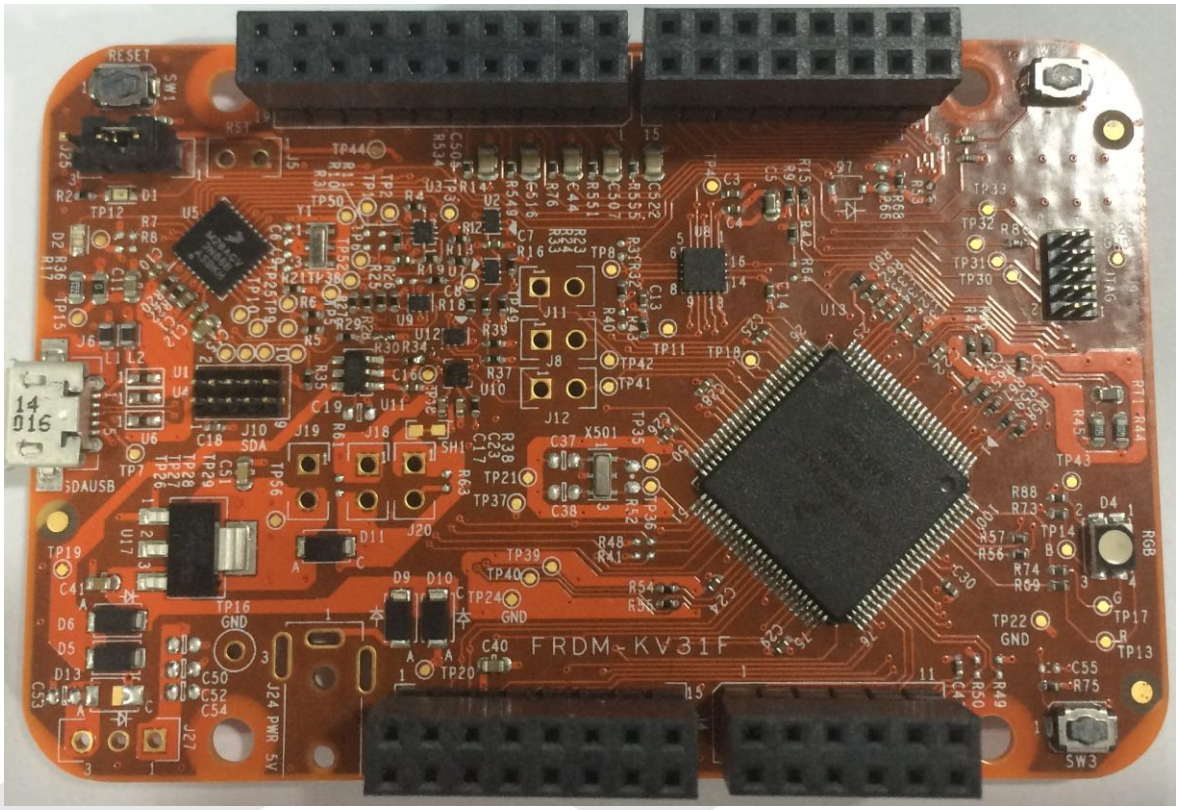
# FRDM-KV31F Board

## User Manual

## FRDM-KV31F

Rev. 0.00




**Freescale Semiconductor Inc.**
*Microcontroller Solutions Group*

# Contents

**1 Introduction ..... 3**
*FRDM-KV31F Hardware Overview ..... 3*
**2 FRDM-K31F hardware description ..... 5**
*Power supply ..... 5*
*Serial and Debug Adapter version 2 (OpenSDAv2) ..... 6*
*Debug interface ..... 7*
*Microcontroller ..... 8*
*Clock Source ..... 9*
*Accelerometer and magnetometer ..... 10*
*Thermistor ..... 11*
*RGB LED ..... 12*
*Serial port ..... 13*
*Reset ..... 13*
*Push button switches ..... 14*
*Input/output connectors ..... 15*
*Arduino compatibility ..... 16*
**3 References ..... 17**
**4 Revision history ..... 17**

# 1 Introduction

The Freescale Freedom development platform is a set of software and hardware tools for evaluation and development. It is ideal for rapid prototyping of microcontroller-based applications.
The Freescale Freedom KV31 hardware, FRDM-KV31F, is a simple, yet sophisticated design featuring a Kinetis K series microcontroller, built on the ARM® Cortex®-M4 core - is a high-performance solution for BLDC, PMSM and ACIM motor control applications.. FRDM-KV31F can be used to evaluate the KV3x Kinetis K series devices. It features the MKV31F512VLL12 MCU, running at 100/120 MHz with DSP and floating point unit, it features dual 16-bit analog-to-digital converters (ADCs) sampling at up to 1.2 mega samples per second (MSPS), multiple motor control timers, 64 to 512 KB of flash memory and a comprehensive enablement suite from Freescale and its third-party resources including reference designs, software libraries and motor configuration tools. The FRDM-KV31F hardware is form-factor compatible with the Arduino™ R3 pin layout, providing a broad range of expansion board options. The onboard interface includes a six-axis digital accelerometer & magnetometer, and a RGB LED. The FRDM-KV31F platform features OpenSDAv2, the Freescale open-source hardware embedded serial and debug adapter running an open-source bootloader. This circuit offers several options for serial communication, flash programming, and run-control debugging. OpenSDAv2 is an mbed™ HDK-compatible debug interface preloaded with the open-source CMSIS-DAP Interface firmware (mbed interface) for rapid prototyping and product development.

FRDM-KV31F Hardware Overview

The features of the FRDM-KV31F hardware are as follows:

- MKV31F512VLL12 MCU (120 MHz with DSP instructions, 512 KB flash memory and 96 KB RAM , motor control timers, and 100 LQFP)
- Dual role USB interface with micro-B USB connector
- RGB LED
- FXOS8700CQ – accelerometer and magnetometer
- Two user push buttons
- Flexible power supply option – OpenSDAv2 USB, and external source
- Easy access to MCU input/output through Arduino R3™ compatible I/O connectors
- Programmable OpenSDAv2 debug circuit supporting the CMSIS-DAP Interface software that provides:
    - Mass storage device (MSD) flash programming interface
    - CMSIS-DAP debug interface over a driver-less USB HID connection providing runcontrol debugging and compatibility with IDE tools o Virtual serial port interface
    - Open-source CMSIS-DAP software project: github.com/mbedmicro/CMSIS-DAP.

Figure 1 shows the block diagram of the FRDM-KV31F design. The primary components and their placement on the hardware assembly are explained in Figure 2.

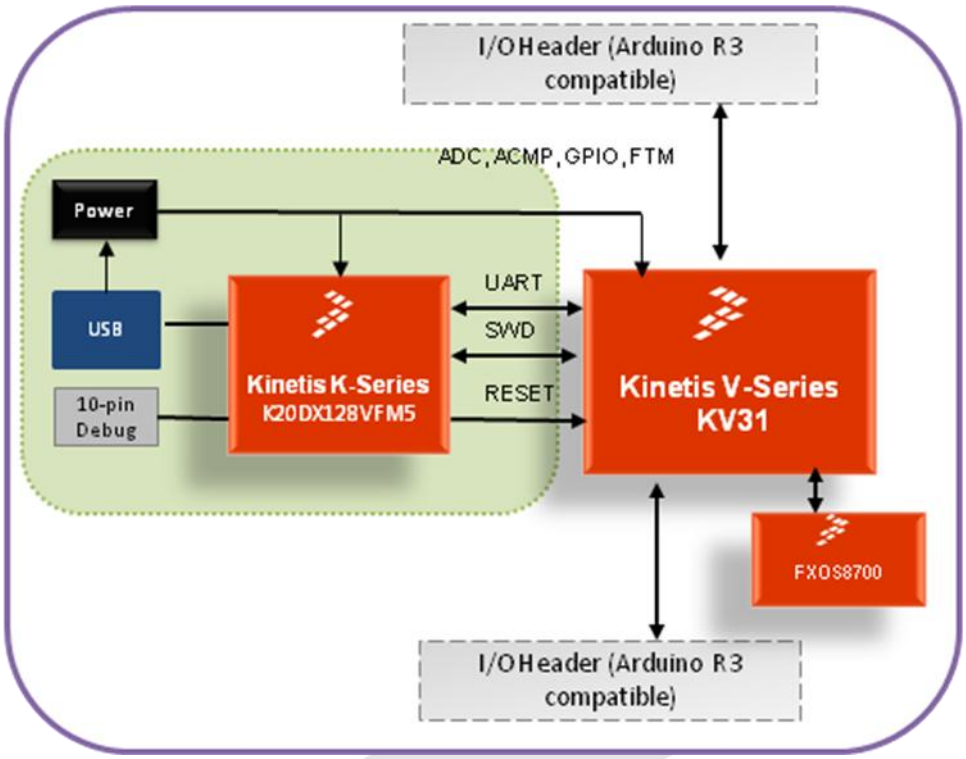



**Figure 1 FRDM-KV31F platform Block Diagram**

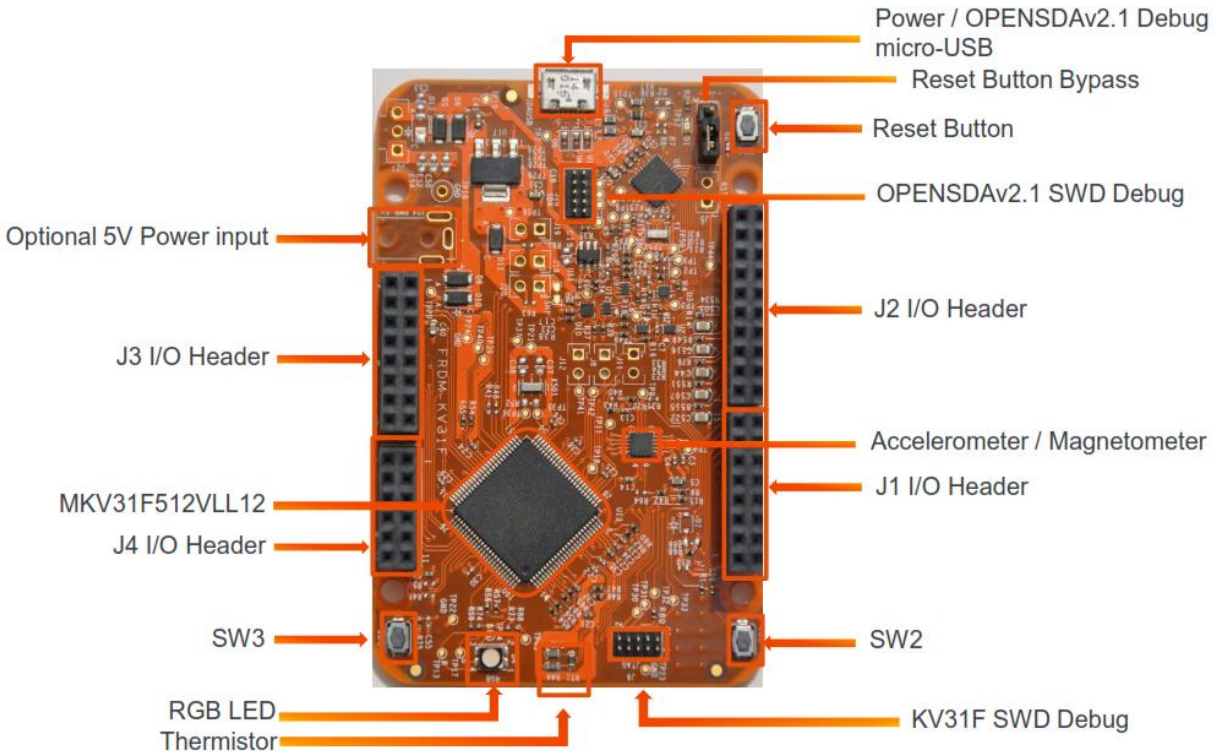



**Figure 2 FRDM-KV31F main components placement**

# 2 FRDM-K31F hardware description

Power supply

There are multiple power supply options on the FRDM-KV31F board. It can be powered from the USB connectors, the VIN pin on the I/O header, DC Jack (not populated), or an offboard 1.71–3.6 V supply from the 3.3 V pin on the I/O header. The USB, DC jack, and VIN supplies are regulated onboard using a 3.3 V linear regulator to produce the main power supply. DC to DC linear regulator is not available in 3.3 V on J20 Header, however a direct supply to KV31 MCU is available. Table 1 provides the operational details and requirements for the power supplies.

**Table 1 Power supply requirements**

| Supply source | Valid range | OpenSDAv2 operational? | Regulated onboard? |
|---|---|---|---|
| OpenSDAv2 USB | 5 V | Yes | Yes |
| VIN Pin | 5 – 9 V | No | Yes |
| 3.3V Header (J20) | 1.71 – 3.6 V | No | No |
| DC Jack (Not Populated) | 5 – 9 V | No | Yes |

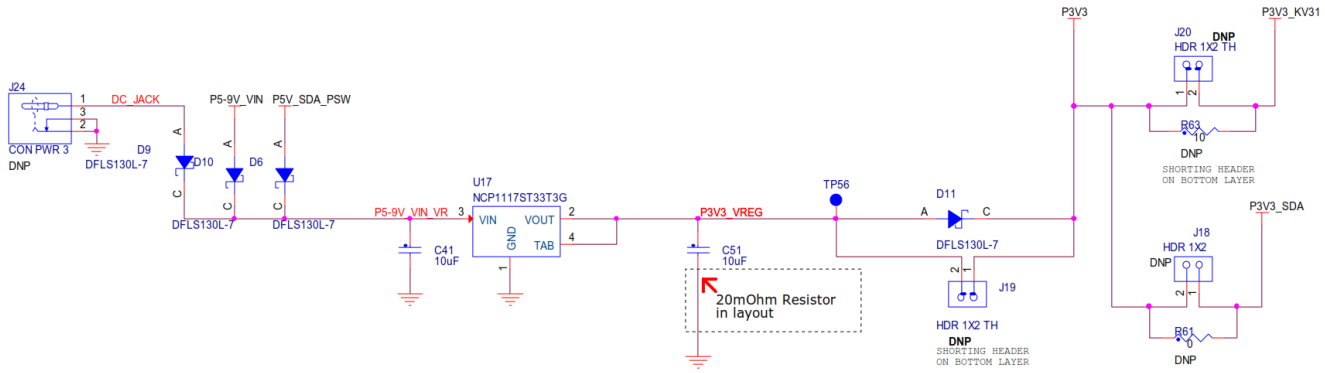
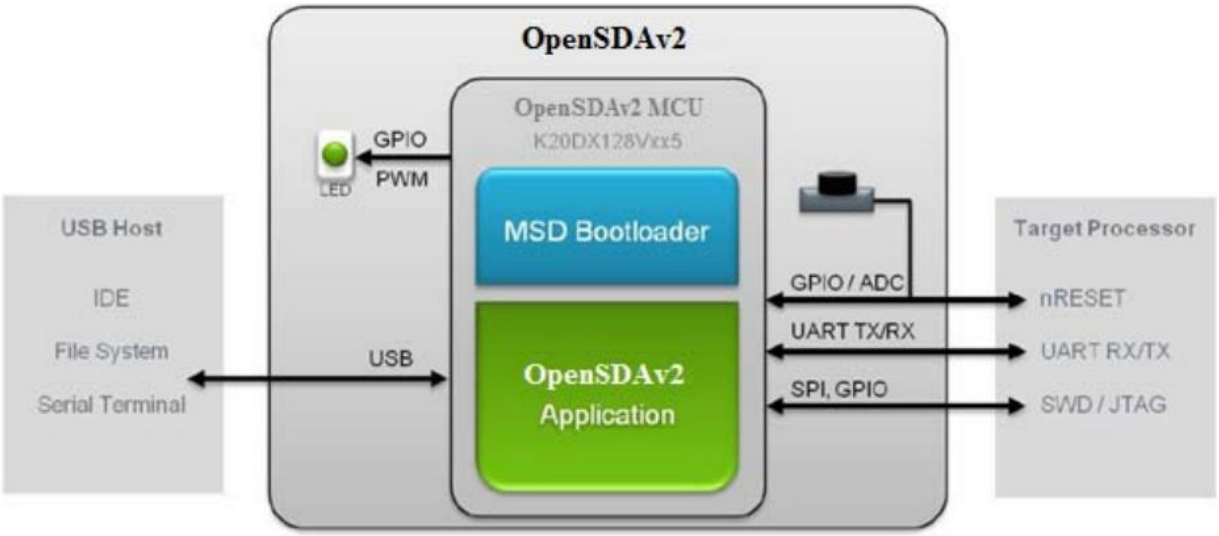



**Figure 3 Power Supply schematic**

Serial and Debug Adapter version 2 (OpenSDAv2)

OpenSDAv2 is a serial and debug adapter circuit which includes an open-source hardware design, an open-source bootloader, and debug interface software. It bridges serial and debug communications between a USB host and an embedded target processor as shown in Figure 4. The hardware circuit is based on a Freescale Kinetis K20 family microcontroller (MCU) with 128 KB of embedded flash and an integrated USB controller. OpenSDAv2 comes preloaded with the CMSIS-DAP bootloader – an open-source mass storage device (MSD) bootloader and the CMSIS-DAP Interface firmware (aka mbed interface), which provides a MSD flash programming interface, a virtual serial port interface, and a CMSIS-DAP debug protocol interface. For more information on the OpenSDAv2 software, see mbed.org and https://github.com/mbedmicro/CMSIS-DAP




Debug interface

Signals with SPI and GPIO capability are used to connect directly to the SWD of KV31. These signals are also brought out to a standard 10-pin (0.05”) Cortex debug connector (J9). It is possible to isolate the KV31 MCU from the OpenSDAv2 circuit and use J9 to connect to an offboard MCU. To accomplish this, cut the trace on the bottom side of the PCB that connects J11 pin 2 to J9 pin 4. This will disconnect the SWD_CLK pin to the KV31 so that it will not interfere with the communications to an offboard MCU connected to J11.

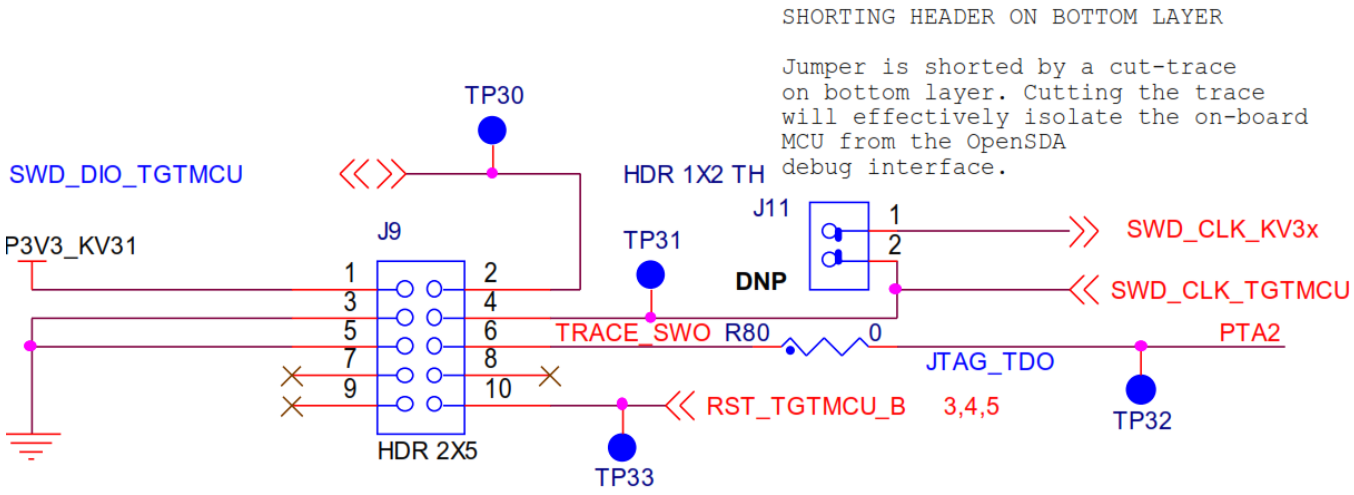



**Figure 4 SWD Debug connecor**

J9 is populated by default. A mating cable, such as a Samtec FFSD IDC cable, can then be used to connect from the OpenSDAv2 of the FRDM-KV31F to an offboard SWD connector.

Virtual serial port
A serial port connection is available between the OpenSDAv2 MCU and pins PTA1 and PTA2 of the KV31

Microcontroller

The FRDM-KV31F features the MKV31F512VLL12 MCU. The KV31 MCU family is a highly scalable member of the Kinetis V series and provides a high-performance, cost-competitive motor control solution. Built on the ARM®Cortex®-M4 core running at 120 MHz, combined with floating point and DSP capability, this is implemented in the 100pin LQFP package. The following table describes some of the features of the MKV31F512VLL12 MCU.

| | |
|---|---|
| Performance | • 120 MHz ARM Cortex-M4 core with DSP instructions delivering 1.25 Dhrystone MIPS per MHz<br>• Dual 16-bit ADCs sampling at up to 1.2 MS/s in 12-bit mode • 20 channels of highly flexible motor control timers (PWMs) across 4 independent time bases • Large RAM block enabling local execution of fast control loops at full clock |

| | |
|---|---|
| | speed |
| Memories and memory interfaces | • 512 KB of embedded flash and 96 KB of RAM • FlexBus external bus interface • Serial programming interface (EzPort) • Preprogrammed Kinetis flashloader for one-time, insystem factory programming |
| System peripherals | • Flexible low-power modes, multiple wake-up sources • 16-channel DMA controller • Independent external and software watchdog monitor |
| Clocks | • One crystal oscillator with two ranges: 32-40 kHz or 3-32 MHz • Three internal oscillators: 32 kHz, 4 MHz, and 48 MHz • Multipurpose clock generator with PLL and FLL |
| Security and integrity modules | • Hardware CRC module • 128-bit unique identification (ID) number per chip • Hardware random-number generator • Flash access control to protect proprietary software |
| Analog modules | • Two 16-bit SAR ADCs (1.2 MS/s in 12bit mode) • Two 12-bit DACs • Two analog comparators (CMP) with 6-bit DAC • Accurate internal voltage reference |
| Timers | • Two 8-ch motor-control/general purpose/PWM timers • Two 2-ch motor-control/general purpose timers with quadrature decoder functionality • Periodic interrupt timers • 16-bit low-power timer • Programmable delay block |
| Communication interfaces | • Two SPI modules • Three UART modules and one low-power UART • Two I2C: Support for up to 1 Mbps operation |

Clock Source

A 8MHz external crystal, is used for the external clock source of the KV31.

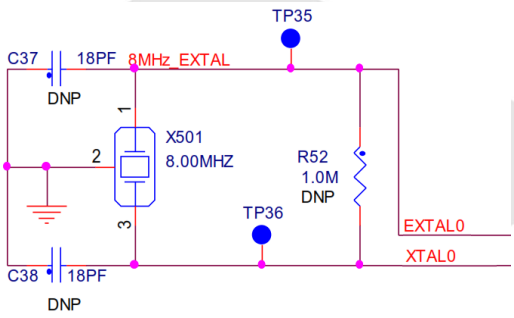



**Figure 5 Clock Source**

Accelerometer and magnetometer

A Freescale FXOS8700CQ low-power, six-axis Xtrinsic sensor is interfaced through an I2C bus and two GPIO signals, as shown in Table 5. By default, the I2C address is 0x1D (SA0 pullup and SA1 pulldown).

**Table 2 Accelerometer and magnetometer signals connections**

| FXOS8700CQ | KV31 |
|---|---|
| SCL | PTD2/LLWU_P13/SPI0_SOUT/UART2_RX/FTM3_CH2/FBA_AD4/LPUART0_RX/I2C0_SCL |
| SDA | PTD3/SPI0_SIN/UART2_TX/FTM3_CH3/FBA_AD3/LPUART0_TX/I2C0_SDA |
| NT1 | PTD0/LLWU_P12/SPI0_PCS0/UART2_RTS/FTM3_CH0/FBA_ALE/FBA_CS1/FBA_TS/LPUART0_RTS |
| INT2 | PTC18/LPUART0_RTS/FBA_TBST/FBA_CS2/FBA_BE15_8_BLS23_16 |

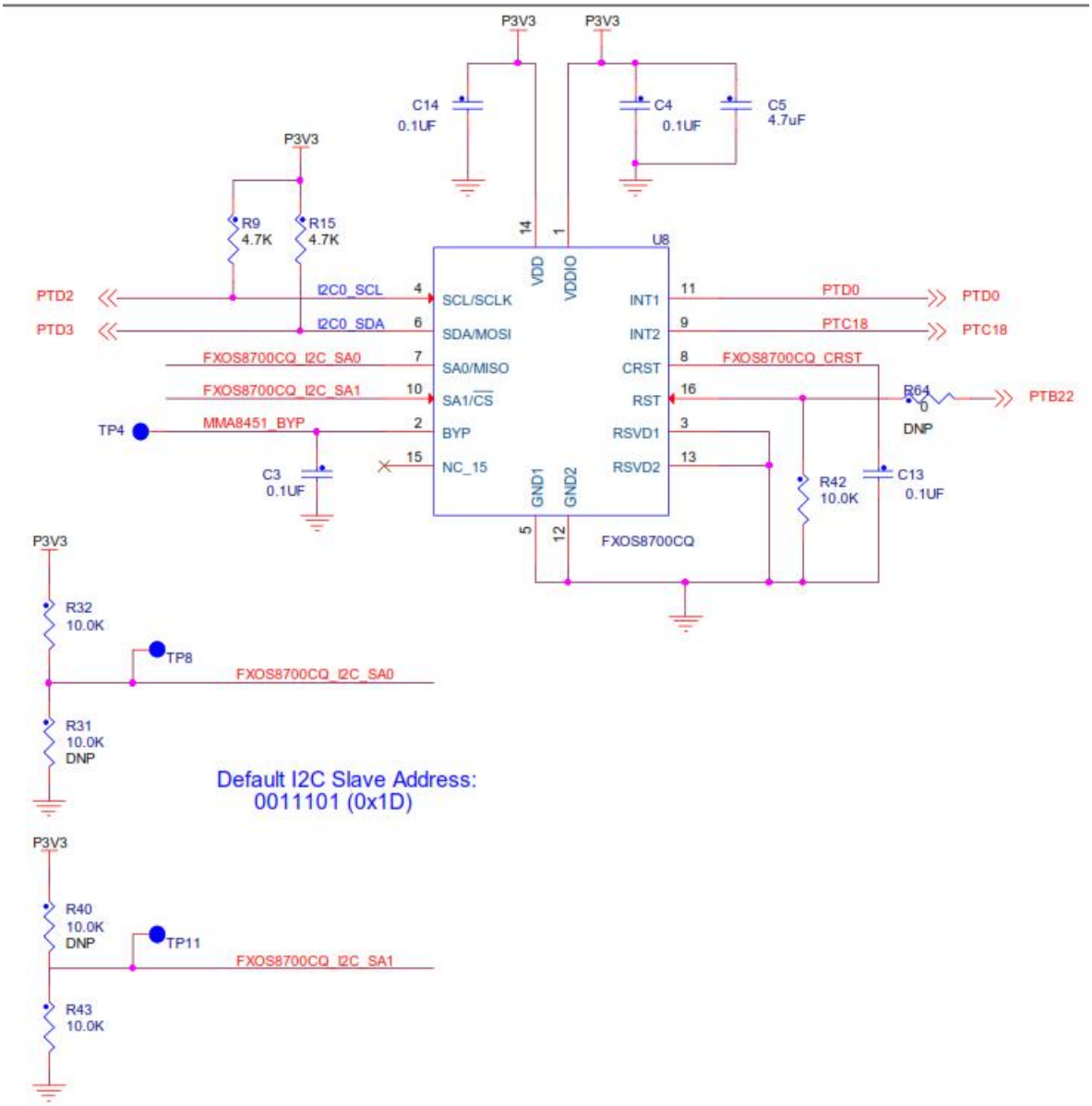



**Figure 6 Accelerometer and Magnetometer**

Thermistor

There is a thermistors RT1 provided on the board that can be used as single ended or differential analog inputs to the KV31.

In addition to the thermistor there is a resistor between the thermistor and 3.3V system power supply and another resistor between the thermistor and ground. The thermistor is a 10K ohm part but the associated divider chain uses different resistors. This makes the voltage across the thermistor larger or smaller and provides the ability to try the different gain settings on the analog channels. The

thermistor circuit is designed to provide useable differential inputs over the temperature range of 90˚C to -20˚C.

In addition to the thermistor voltage divider chain, the thermistor has a 0.1 uF capacitor in parallel. Each analog input to the KV31 has a 100 ohm series resistor and a 2200pF capacitor as a low pass filter. This helps protect the KV31 from electrostatic discharges and lowers the impedance of the analog signal so that it can be sampled with less noise.

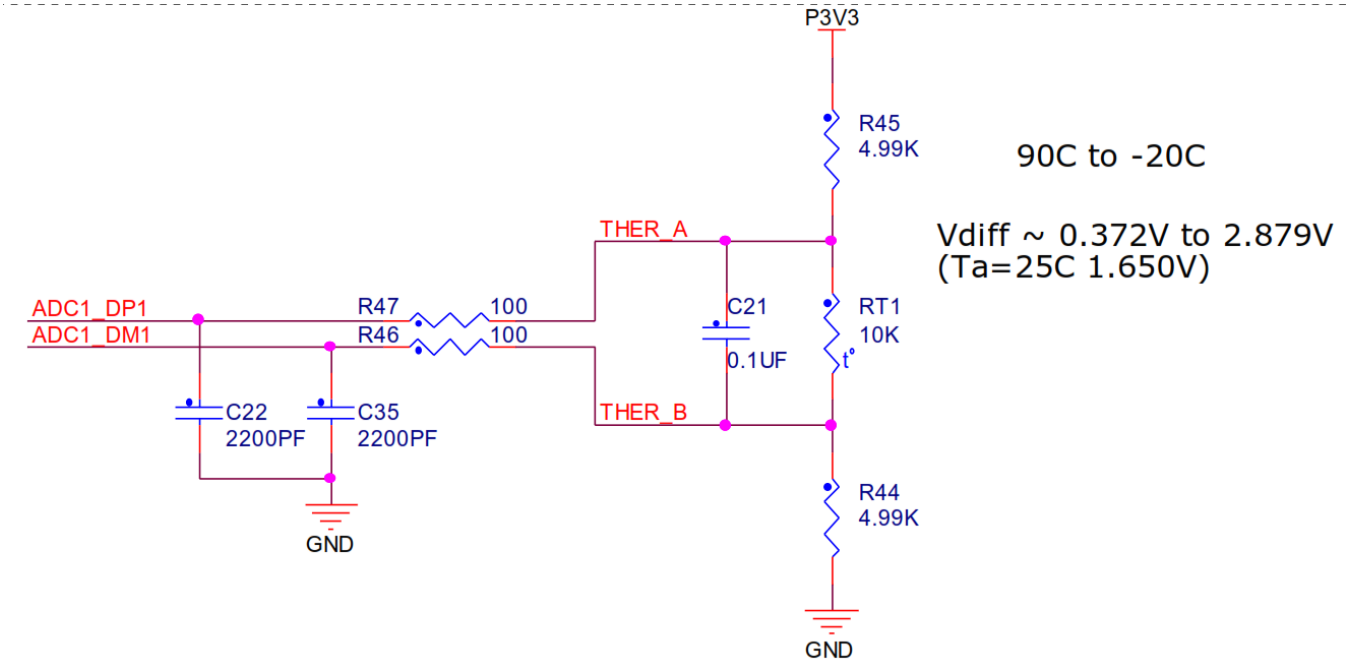



**Figure 7 Thermistor**

RGB LED

RGB LED is connected through GPIO, signal connections are shown in Table.

**Table 3 LED Signal connections**

| RGB LED | KV31 |
|---|---|
| RED | PTD1/ADC0_SE5B/SPI0_SCK/UART2_CTS/FTM3_CH1/FBA_CS0/LPUART0_CTS |
| BLUE | PTE25/ADC0_SE18/FTM0_CH1/I2C0_SDA/EWM_IN |
| GREEN | TD7/UART0_TX/FTM0_CH7/FTM0_FLT1/SPI1_SIN |

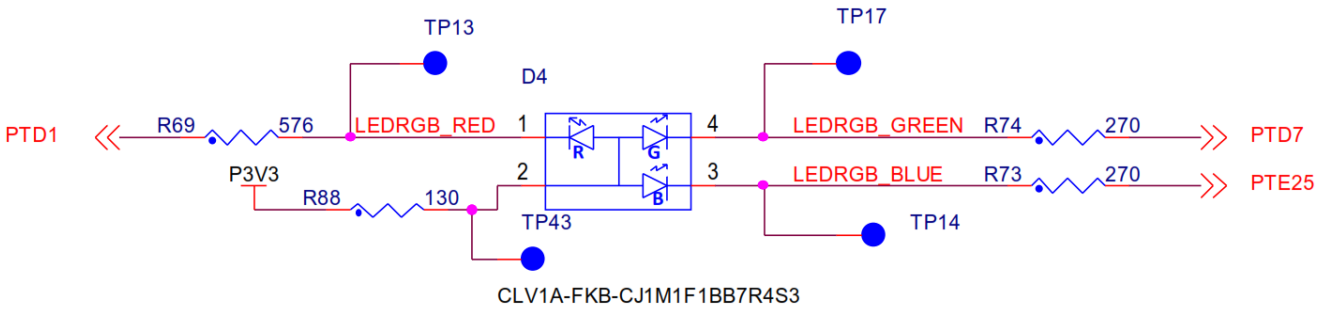



**Figure 8 RGB LED**

Serial port

The primary serial port interface signals are PTB16 UART0_RX and PTB17 UART0_TX. These signals are connected to the OpenSDAv2 circuit.

Reset

The RESET signal on the K20 is connected externally to a pushbutton, named SW1, and also to the OpenSDAv2 circuit. The reset button can be used to force an external reset event on the target MCU. The reset button can also be used to force the OpenSDAv2 circuit into boot loader mode. For more details, see Serial and debug adapter (OpenSDAv2).

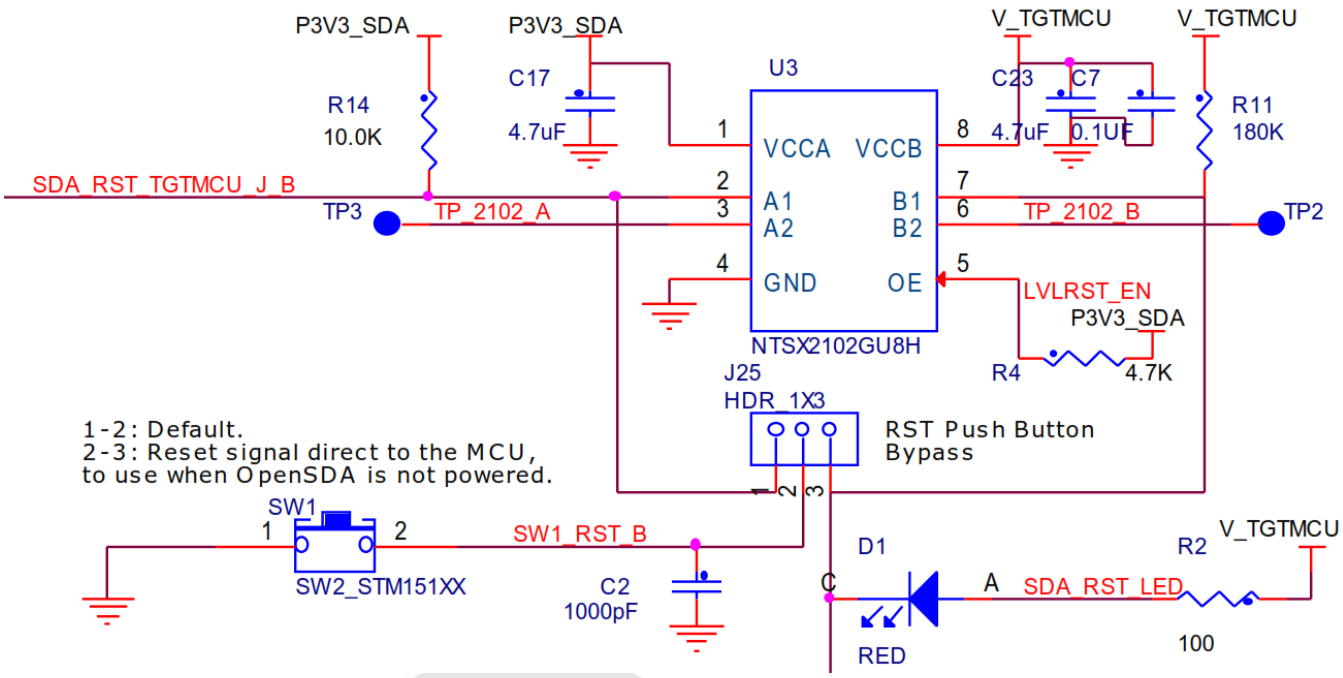



**Figure 9 Reset circuit**

Push button switches

Two push buttons, SW2 and SW3, are available on FRDM-K64F board, where SW2 is connected to PTC6 and SW3 is connected to PTA4. Besides the general purpose input/output functions, SW2 and SW3 can be low-power wake up signal. Also, only SW3 can be a non-maskable interrupt.

**Table 4 Push button GPIO function**

| Switch | GPIO Function |
|---|---|
| SW2 | PTA4/LLWU_P3/FTM0_CH1/FTM0_FLT3/NMI/EZP_CS |
| SW3 | PTE4/LLWU_P2/SPI1_PCS0/LPUART0_TX |

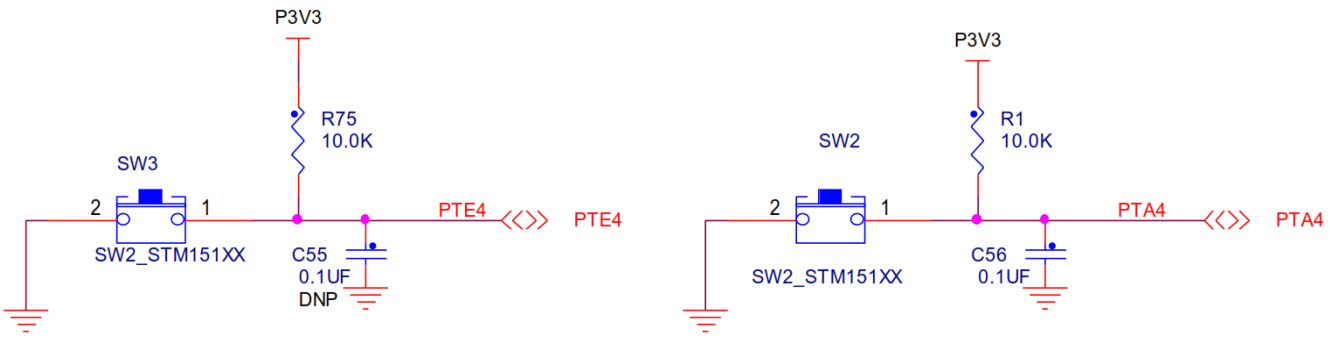



**Figure 10 Pushbutton switches**

Input/output connectors

The MKV31F512VLL12 microcontroller is packaged in a 100-pin LQFP. Some pins are utilized in onboard circuitry, but some are directly connected to one of the four I/O headers. The pins on the KV31 microcontroller are named for their general purpose input/output port pin function. For example, the first pin on Port A is referred as PTA1. The name assigned to the I/O connector pin is same as of the KV31 pin connected to it, if applicable.

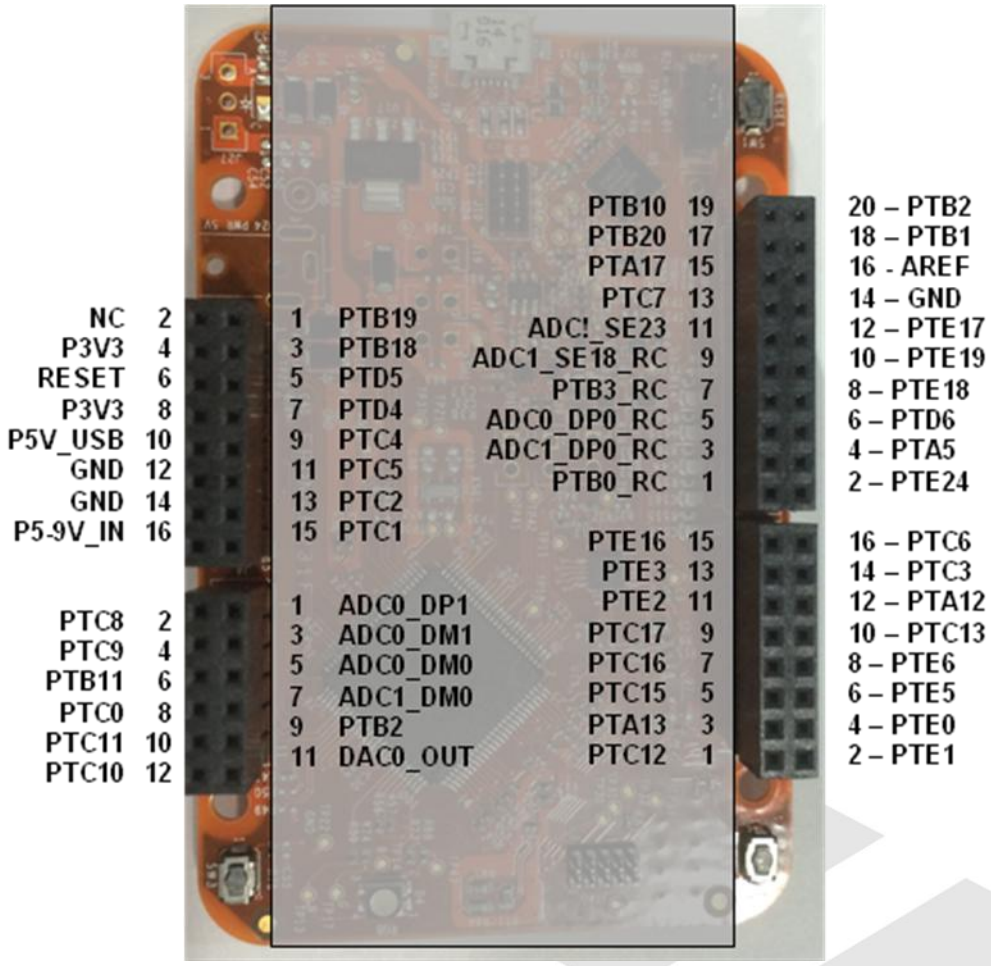



**Figure 11 IO header pinout**

Arduino compatibility

The I/O headers on the FRDM-KV31F board are arranged to enable compatibility with peripheral boards (known as shields) that connect to Arduino and Arduino-compatible microcontroller boards. The outer rows of pins (even numbered pins) on the headers, share the same mechanical spacing and placement with the I/O headers on the Arduino Revision 3 (R3) standard.

# 3 References

The following references are available on freescale.com :

- FRDMKV31FQSG, FRDM-KV31F Quick Start Guide
- FRDM-KV31F Pinouts
- FRDM-KV31F Schematic
- FRDM-KV31F Design Package

# 4 Revision history

| Revision number | Date | Substantial changes |
|---|---|---|
| 0 | 06/2015 | Initial release |